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THE PROGRESS OF PHYSICS IN THE NINETEENTH CENTURY.

II.

DIFFRACTION.

Though diffraction dates back to Grimaldi (1665) and was well known to Newton (1704), the first correct though crude interpretation of the phenomenon is due to Young (1802, 1804). Independently Fresnel (1815) in his original work devised similar explanations, but later (1818, 1819, 1826) gave a more rational theory in terms of Huyghens's principle, which he was the first to adequately interpret. Fresnel showed that all points of a wave front are concerned in producing diffraction, though the ultimate critical analysis was left to Stokes (1849).

In 1822 Fraunhofer published his remarkable paper, in which, among other inventions, he introduced the grating into science. Zone plates were studied by Cornu (1875) and by Soret (1875). Rowland's concave grating appeared in 1881. Michelson's echelon spectrometer in 1899.

The theory of gratings and other diffraction phenomena was exhaustively treated by Schwerd (1837). Babinet established the principle bearing his name in 1837. Subsequent developments were in part concerned with the improvement of Fresnel's method of computation, in part with a more rigorous treatment of the theory of diffraction. Stokes (1850, 1852) gave the first account of the polarization accompanying diffraction, and thereafter Rayleigh (1871) and many others, including

Kirchhoff (1882, 1883), profoundly modified the classic treatment. Airy (1834, 1838) and others elaborately examined the diffraction due to a point source in view of its important bearing on the efficiency of optical instruments.

A unique development of diffraction is the phenomenon of scattering propounded by Rayleigh (1871) in his dynamics of the blue sky. This great theory which Rayleigh has repeatedly improved (1881, et seq.) has since superseded all other relevant explanations.

POLARIZATION.

An infinite variety of polarization phenomena grew out of Bartholinus's (1670) discovery. Sound beginnings of a theory were laid by Huyghens ('Traité,' 1690), whose wavelet principle and elementary wave front have persisted as an invaluable acquisition, to be generalized by Fresnel in 1821.

Fresh foundations in this department of optics were laid by Malus (1810) in his discovery of the cosine law and the further discovery of the polarization of reflected light. Later (1815) Brewster adduced the conditions of maximum polarization for this case.

In 1811 Arago announced the occurrence of interferences in connection with parallel plane-polarized light, phenomena which under the observations of Arago and Fresnel (1816, 1819), Biot (1816), Brewster (1813, 1814, 1818) and others grew immensely in variety, and in the importance of their bearing on the undulatory theory. It is on the basis of these phenomena that Fresnel in 1819 insisted on the transversality of light waves, offering proof which was subsequently made rigorous by Verdet (1850). Though a tentative explanation was here again given by Young (1814), the first adequate theory of the behavior of thin plates of aeolotropic media with polarized light came from Fresnel (1821).

Airy (1833) elucidated a special case of the gorgeously complicated interferences obtained with convergent pencils; Neumann in 1834 gave the general theory. The forbidding equations resulting were geometrically interpreted by Bertin (1861, 1884), and Lommel (1883) and Neumann (1841) added a theory for stressed media, afterwards improved by Pockels (1889).

The peculiarly undulatory character of natural light owes its explanation largely to Stokes (1852), and his views were verified by many physicists, notably by Fizeau (1862) showing interferences for path differences of 50,000 wave-lengths and by Michelson for much larger path differences.

The occurrence of double refraction in all non-regular crystals was recognized by Haüy (1788) and studied by Brewster (1818). In 1821, largely by a feat of intuition, Fresnel introduced his generalized elementary wave surface, and the correctness of his explanation has since been substantiated by a host of observers. Stokes (1862, et seq.) was unremittingly active in pointing out the theoretical bearing of the results obtained. Hamilton (1832) supplied a remarkable criterion of the truth of Fresnel's theory deductively, in the prediction of both types of conic refraction. The phenomena were detected experimentally by Lloyd (1833).

The domain of natural rotary polarization, discovered by Arago (1811) and enlarged by Biot (1815), has recently been placed in close relation to non-symmetrical chemical structure by LeBel (1874) and van't Hoff (1875), and a tentative molecular theory was advanced by Sohncke (1876).

Boussinesq (1868) adapted Cauchy's theory (1842) to these phenomena. Independent elastic theories were propounded

by MacCullagh (1837), Briot, Sarrau (1868); but there is naturally no difficulty in accounting for rotary polarization by the electromagnetic theory of light, as was shown by Drude (1892).

Among investigational apparatus of great importance the Soleil (1846, 1847) saccharimeter may be mentioned.

THEORIES.

In conclusion, a brief summary may be given of the chief mechanisms proposed to account for the undulations of light. Fresnel suggested the first adequate optical theory in 1821, which, though singularly correct in its bearing on reflection and refraction in the widest sense, was merely tentative in construction. Cauchy (1829) proposed a specifically elastic theory for the motion of relatively long waves of light in continuous media, based on a reasonable hypothesis of molecular force, and deduced therefrom Fresnel's reflection and refraction equations. Green (1838), ignoring molecular forces and proceeding in accordance with his own method in elastics, published a different theory, which did not, however, lead to Fresnel's equations. Kelvin (1888) found the conditions implied in Cauchy's theory compatible with stability if the ether were considered as bound by a rigid medium. The ether implied throughout is to have the same elasticity everywhere, but to vary in density from medium to medium, and vibration to be normal to the plane of polarization.

Neumann (1835), whose work has been reconstructed by Kirchhoff (1876), and MacCullagh (1837), with the counter-hypothesis of an ether of fixed density but varying in elasticity from medium to medium, also deduced Fresnel's equations, obtaining at the same time better surface conditions in the case of æolotropic media. The vibrations are in the plane of polarization.

All the elastic theories essentially predict a longitudinal light wave. It was not until Kelvin in 1889, 1890 proposed his remarkable gyrostatic theory of light, in which force and displacement become torque and twist, that these objections to the elastic theory were wholly removed. MacCullagh, without recognizing their bearing, seems actually to have anticipated Kelvin's equation.

With the purpose of accounting for dispersion, Cauchy in 1835 gave greater breadth to his theory by postulating a sphere of action of ether particles commensurate with wave-length, and in this direction he was followed by F. Neumann (1841), Briot (1864), Rayleigh (1871) and others, treating an ether variously loaded with material particles. Among theories beginning with the phenomena observed, that of Boussinesq (1867, et seq.) has received the most extensive development.

The difficult surface conditions met with when light passes from one medium to another, including such subjects as ellipticity, total reflection, etc., have been critically discussed, among others, by Neumann (1835) and Rayleigh (1888); but the discrimination between the Fresnel and the Neumann vector was not accomplished without misgiving before the advent of the work of Hertz.

It appears, therefore, that the elastic theories of light, if Kelvin's gyrostatic adynamic ether be admitted, have not been wholly routed. Nevertheless, the great electromagnetic theory of light propounded by Maxwell (1864, 'Treatise,' 1873) has been singularly apt not only in explaining all the phenomena reached by the older theories and in predicting entirely novel results, but in harmoniously uniting as parts of a unique doctrine, both the electric

or photographic light vector of Fresnel and Cauchy and the magnetic vector of Neumann and MacCullagh. Its predictions have, moreover, been astonishingly verified by the work of Hertz (1890), and it is to-day acquiring added power in the convection theories of Lorentz (1895) and others.

ELECTROSTATICS.

Coulomb's (1785) law antedates the century; indeed, it was known to Cavendish (1771, 1781). Problems of electric distribution were not seriously approached, however, until Poisson (1811) solved the case for spheres in contact. Afterwards Clausius (1852), Helmholtz (1868) and Kirchhoff (1877) examined the conditions for discs, the last giving the first rigorous theory of the experimentally important plate condenser. In 1845, 1848 the investigation of electric distribution received new incentive as an application of Kelvin's beautiful method of images. Maxwell ('Treatise,' 1873) systematized the treatment of capacity and induction coefficients.

Riess (1837) in a classic series of experiments on the heat produced by electrostatic discharge virtually deduced the potential energy of a conductor and in a measure anticipated Joule's law (1841). In 1860 appeared Kelvin's great paper on the electromotive force needed to produce a spark. As early as 1855, however, he had shown that the spark discharge is liable to be of the character of a damped vibration and the theory of electric oscillation was subsequently extended by Kirchhoff (1867). The first adequate experimental verification is due to Feddersen (1858, 1861).

The specific inductive capacity of a medium with its fundamental bearing on the character of electric force was discovered by Faraday in 1837. Of the theories propounded to account for this property the most far reaching is Maxwell's (1865), which culminates in the unique result showing that the refraction index of a medium is the square root of its specific inductive capacity. With regard to Maxwell's theory of the Faraday stress in the ether as compared with the subsequent development of electrostriction in other media by many authors, notably by Boltzmann (1880) and by Kirchhoff (1885), it is observable that the tendency of the former to assign concrete physical properties to the tube of force is growing, particularly in connection with radioactivity. Duhem (1892, 1895) insists, however, on the greater trustworthiness of the thermodynamic potential.

The seemingly trivial subject of pyroelectricity interpreted by Æpinus (1756) and studied by Brewster (1825), has none the less elicited much discussion and curiosity, a vast number of data by Hankel (1839–93) and others and a succinct explanation by Kelvin (1860, 1878). Similarly piezoelectricity, discovered by the brothers Curie (1880), has been made the subject of a searching investigation by Voigt (1890). Finally Kerr (1875, et seq.) observed the occurrence of double refraction in an electrically polarized medium. Recent researches, among which those of Lemoine (1896) are most accurate, have determined the phase difference corresponding to the Kerr effect under normal conditions, while Voigt (1899) has adduced an adequate theory.

Certain electrostatic inventions have had a marked bearing on the development of electricity. We may mention in particular Kelvin's quadrant electrometer (1867) and Lippmann's capillary electrometer (1873). Moreover, among apparatus originating in Nicholson's duplicator (1788) and Volta's electrophorus, the Töpler-Holtz machine (1865–67), with the recent improvement due to Wimshurst, has

replaced all others. Atmospheric electricity, after the memorable experiment of Franklin (1751), made little progress until Kelvin (1860) organized a systematic attack. More recently a revival of interest began with Exner (1886), but more particularly with Linss (1887), who insisted on the fundamental importance of a detailed knowledge of atmospheric conduction. It is in this direction that the recent vigorous treatment of the atmosphere as an ionized medium has progressed, owing chiefly to the indefatigable devotion of Elster and Geitel (1899, et seq.) and of C. T. R. Wilson (1897, et seq.). Qualitatively the main phenomena of atmospheric electricity are now plausibly accounted for; quantitatively there is as yet very little specific information.

VOLTA CONTACTS.

Volta's epoch-making experiment of 1797 may well be added to the century which made such prolific use of it; indeed, the Voltaic pile (1800–02) and Volta's law of series (1802) come just within it. Among the innumerable relevant experiments Kelvin's dropping electrodes (1859) and his funnel experiment (1867) are among the more interesting, while the 'Spannungsreihe' of R. Kohlrausch (1851, 1853) is the first adequate investigation. Nevertheless, the phenomenon has remained without a universally acceptable explanation until the present day, when it is reluctantly yielding to electronic theory, although ingenious suggestions like Helmholtz's 'Doppelschicht' (1879), the interpretations of physical chemistry and the discovery of the concentration cell (Helmholtz; Nernst, 1888, 1889; Planck, 1890) have thrown light upon it.

Among the earliest theories of the galvanic cell is Kelvin's (1851, 1860), which, like Helmholtz's, is incomplete. The most satisfactory theory is Nernst's (1889). Gibbs (1878) and Helmholtz (1882) have made searching critical contributions, chiefly in relation to the thermal phenomena.

Volta's invention was made practically efficient in certain famous galvanic cells, among which Daniell's (1836), Grove's (1839), Clarke's (1878), deserve mention, and for the purposes of measurement have been subserved by the potentiometers of Poggendorff (1841), Bosscha (1855), Clarke (1873).

SEEBECK CONTACTS.

Thermoelectricity, destined to advance many departments of physics, was discovered by Seebeck in 1821. The Peltier effect followed in 1834, subsequently to be interpreted by Icilius (1853). A thermodynamic theory of the phenomena came from Clausius (1853) and with greater elaboration, together with the discovery of the Thomson effect, from Kelvin (1854, 1856), to whom the thermoelectric diagram is due. This was subsequently developed by Tait (1872, et seq.) and his pupils. Avenarius (1863), however, first observed the thermoelectric parabola.

The modern platinum-iridium or platinum-rhodium thermoelectric pyrometer dates from about 1885 and has recently been perfected at the Reichsanstalt. Melloni (1835, et seq.) made the most efficient use of the thermopyle in detecting minute temperature differences.

ELECTROLYSIS.

Though recognized by Nichols and Carlisle (1800) early in the century, the laws of electrolysis awaited the discovery of Faraday (1834). Again, it was not till 1853 that further marked advances were made by Hittorf's (1853–59) strikingly original researches on the velocities of the ions. Later Clausius (1857) suggested an adequate theory of electrolysis, which was

subsequently to be specialized in the dissociation hypothesis of Arrhenius (1881, 1884). To the elaborate investigations of F. Kohlrausch (1879, et seq.), however, science owes the fundamental law of the independent velocities of migration of the ions.

Polarization discovered by Ritter in 1803 became in the hands of Plante (1859–1879) an invaluable means for the storage of energy, an application which was further improved by Faure (1880).

STEADY FLOW.

The fundamental law of the steady flow of electricity, in spite of its simplicity, proved to be peculiarly elusive. True, Cavendish (1771–81) had definite notions of electrostatic resistance as dependent on length section and potential, but his intuitions were lost to the world. Davy (1820), from his experiments on the resistances of conductors, seems to have arrived at the law of sections, though he obscured it in a misleading statement. Barlow (1825) and Becquerel (1825–26), the latter operating with the ingenious differential galvanometer of his own invention, were not more definite. Surface effects were frequently suspected. Ohm himself, in his first paper (1825), confused resistance with the polarization of his battery, and it was not till the next year (1826) that he discovered the true law, eventually promulgated in his epoch-making 'Die galvanische Kette' (1827).

It is well known that Ohm's mathematical deductions were unfortunate, and would have left a gap between electrostatics and voltaic electricity. But after Ohm's law had been further experimentally established by Fechner (1830), the correct theory was given by Kirchhoff (1849) in a way to bridge over the gap specified. Kirchhoff approached the question gradually, considering first the distribution of current in a plane conductor (1845–1846), from which he passed to the laws of distribution in branched conductors (1847–48)—laws which now find such universal application. In his great paper, moreover, Kirchhoff gives the general equation for the activity of the circuit and from this Clausius (1852) soon after deduced the Joule effect theoretically. The law, though virtually implied in Riess's results (1837), was experimentally discovered by Joule (1841).

As bearing critically or otherwise on Ohm's law we may mention the researches of Helmholtz (1852), of Maxwell (1876), the solution of difficult problems in regard to terminals or of the resistance of special forms of conductors, by Rayleigh (1871, 1879), Hicks (1883) and others, the discussion of the refraction of lines of flow by Kirchhoff (1845), and many researches on the limits of accuracy of the law.

Finally, in regard to the evolution of the modern galvanometer from its invention by Schweigger (1820), we may enumerate in succession Nobili's astatic system (1834), Poggendorff's (1826) and Gauss's (1833) mirror device, the aperiodic systems, Weber's (1862) and Kelvin's critical study of the best condition for galvanometry, so cleverly applied in the instruments of the latter. Kelvin's siphon recorder (1867), reproduced in the Depretz-D'Arsonval system (1882), has adapted the galvanometer to modern conditions in cities. For absolute measurement Pouillet's tangent galvanometer (1837), treated for absolute measurement by Weber (1840), and Weber's dynamometer (1846) have lost little of their original importance.

MAGNETISM.

Magnetism, definitely founded by Gilbert (1600) and put on a quantitative basis by Coulomb (1785), was first made the subject of recondite theoretical treatment by

Poisson (1824–27). The interpretation thus given to the mechanism of two conditionally separable magnetic fluids facilitated discussion and was very generally used in argument, as for instance by Gauss (1833) and others, although Ampère had suggested the permanent molecular current as early as 1820. Weber (1852) introduced the revolable molecular magnet, a theory which Ewing (1890) afterwards generalized in a way to include magnetic hysteresis. The phenomenon itself was independently discovered by Warburg (1881) and by Ewing (1882) and has since become of special practical importance.

Faraday in 1852 introduced his invaluable conception of lines of magnetic force, a geometric embodiment of Gauss's (1813, 1839) theorem of force flux, and Maxwell (1855, 1862, et seq.) thereafter gave the rigorous scientific meaning to this conception, which pervades the whole of cotemporaneous electromagnetics.

The phenomenon of magnetic induction, treated hypothetically by Poisson (1824–27) and even by Barlow (1820), has since been attacked by many great thinkers, like F. Neumann (1848), Kirchhoff (1854); but the predominating and most highly elaborated theory is due to Kelvin (1849, et seq.). This theory is broad enough to be applicable to æolotropic media and to it the greater part of the notation in current use throughout the world is due. A new method of attack of great promise has, however, been introduced by Duhem (1888, 1895, et seq.) in his application of the thermodynamic potential to magnetic phenomena.

Magneticians have succeeded in expressing the magnetic distribution induced in certain simple geometrical figures like the sphere, the spherical shell, the ellipsoid, the infinite cylinder, the ring. Green in 1828 gave an original but untrustworthy treatment for the finite cylinder. Lamellar and solenoidal distributions are defined by Kelvin (1850), to whom the similarity theorems (1856) are also due. Kirchhoff's results for the ring were practically utilized in the absolute measurements of Stoletow (1872) and of Rowland (1878).

Dimagnetism, though known since Brugmans (1778), first challenged the permanent interest of science in the researches of Becquerel (1827) and of Faraday (1845). It is naturally included harmoniously in Kelvin's great theory (1847, et seq.). Independent explanations of diamagnetism, however, have by no means abandoned the field; one may instance Weber's (1852) ingenious generalization of Ampère's molecular currents (1820) and the broad critical deductions of Duhem (1889) from the thermodynamic potential. For the treatment of æolotropic magnetic media, Kelvin's (1850, 1851) theory seems to be peculiarly applicable. Weber's theory would seem to lend itself well to electronic treatment.

The extremely complicated subject of magnetostriction, originally observed by Matteuci (1847) and by Joule (1849) in different cases, and elaborately studied by Wiedemann (1858, et seq.), has been repeatedly attacked by theoretical physicists, among whom Helmholtz (1881), Kirchhoff (1885), Boltzmann (1879) and Duhem (1891) may be mentioned. None of the carefully elaborated theories accounts in detail for the facts observed.

The relations of magnetism to light have increased in importance since the fundamental discoveries of Faraday (1845) and of Verdet (1854), and they have been specially enriched by the magneto-optic discoveries of Kerr (1876, et seq.), of Kundt (1884, et seq.), and more recently by the Zeemann effect (1897, et seq.). Among the theories put forth for the latter, the electronic explanation of Lorentz (1898, 1899) and that of Voigt (1899) are

supplementary or at least not contradictory. The treatment of the Kerr effect has been systematized by Drude (1892, 1893). The instantaneity of the rotational effect was first shown by Bichat and Blondlot (1882) and this result has since been found useful in chronography. Sheldon demonstrated the possibility of reversing the Faraday effect. Finally terrestrial magnetism was revolutionized and made accessible to absolute measurement by Gauss (1833), and his method served Weber (1840, et seq.) and his successors as a model for the definition of absolute units throughout physics. Another equally important contribution from the same great thinker (1840) is the elaborate treatment of the distribution of terrestrial magnetism, the computations of which have been twice modernized, in the last instance by Neumeyer[1] (1880). Magnetometric methods have advanced but little since the time of Gauss (1833), and Weber's (1853) earth inductor remains a standard instrument of research. Observationally, the development of cycles of variation in the earth's constants is looked forward to with eagerness, and will probably bear on an adequate theory of terrestrial magnetism, yet to be framed. Arrhenius (1903) accentuates the importance of the solar cathode torrent in its bearing on the earth's magnetic phenomena.

ELECTROMAGNETISM.

Electromagnetism considered either in theory or in its applications is, perhaps, the most conspicuous creation of the nineteenth century. Beginning with Oersted's great discovery of 1820, the quantitative measurements of Biot and Savart (1820) and Laplace's (1821) law followed in quick succession. Ampère (1820) without delay propounded his famous theory of magnetism. For many years the science was conveniently subserved by Ampère's swimmer (1820), though his functions have since advantageously yielded to Fleming's hand rule for moving current elements. The induction produced by ellipsoidal coils or the derivative cases is fully understood. In practise the rule for the magnetic circuit devised by the Hopkinsons (1886) is in general use. It may be regarded as a terse summary of the theories of Euler (1780), Faraday, Maxwell and particularly Kelvin (1872), who already made explicit use of it. Nevertheless, the clear-cut practical interpretation of the present day had to be gradually worked out by Rowland (1873, 1884), Bosanquet (1883–85), Kapp (1885) and Pisati (1890).

The construction of elementary motors was taken up by Faraday (1821), Ampère (1822), Barlow (1822) and others, and they were treated rather as laboratory curiosities; for it was not until 1857 that Siemens devised his shuttle wound armature and the development of the motor thereafter went *pari passu* with the dynamo to be presently considered. It culminated in a new principle in 1888 when Ferraris, and somewhat later Tesla (1888) and Borel (1888), introduced polyphase transmission and the more practical realization of Arago's rotating magnetic field (1824).

Theoretical electromagnetics, after a period of quiescence, was again enriched by the discovery of the Hall effect (1879, et seq.), which at once elicited wide and vigorous discussion, and for which Rowland (1880), Lorentz (1883), Boltzmann (1886) and others put forward theories of continually increasing finish. Nernst and V. Ettingshausen (1886, 1887) afterwards added the thermomagnetic effect.

[1] Dr. L. A. Bauer kindly called my attention to the more recent work of A. Schmidt, summarized in Dr. Bauer's own admirable paper.

ELECTRODYNAMICS.

The discovery and interpretation of electrodynamic phenomena were the burden of the unique researches of Ampère (1820, et seq., 'Memoir,' 1826). Not until 1846, however, were Ampère's results critically tested. This examination came with great originality from Weber using the bifilar dynamometer of his own invention. Grassmann (1845), Maxwell (1873) and others have invented elementary laws differing from Ampère's; but as Stefan (1869) showed that an indefinite number of such laws might be constructed to meet the given integral conditions, the original law is naturally preferred.

INDUCTION.

Faraday (1831, 1832) did not put forward the epoch-making discovery of electrokinetic induction in quantitative form, as the great physicist was insufficiently familiar with Ohm's law. Lentz, however, soon supplied the requisite interpretation in a series of papers (1833, 1835) which contain his well-known law both for the mutual inductions of circuits and of magnets and circuits. Lentz clearly announced that the induced quantity is an electromotive force, independent of the diameter and metal and varying, *cæt. par.*, with the number of spires. The mutual induction of circuits was first carefully studied by Weber (1846), later by Filici (1852), using a zero method, and Faraday's self-induction by Edlund (1849), while Matteuci (1854) attested the independence of induction of the interposed non-magnetic medium. Henry (1842) demonstrated the successive induction of induced currents.

Curiously enough the occurrence of eddy currents in massive conductors moving in the magnetic field was announced from a different point of view by Arago (1824–26) long before Faraday's great discovery. They were but vaguely understood, however, until Foucault (1855) made his investigation. The general problem of the induction to be anticipated in massive conductor is one of great interest and Helmholtz (1870), Kirchhoff (1891), Maxwell (1873), Hertz (1880) and others have treated it for different geometrical figures.

The rigorous expression of the law of induction was first obtained by F. Neumann (1845, 1847) on the basis of Lentz's law, both for circuits and for magnets. W. Weber (1846) deduced the law of induction from his generalized law of attraction. More acceptably, however, Helmholtz (1847), and shortly after him Kelvin (1848), showed the law of induction to be a necessary consequence of the law of the conservation of energy, of Ohm's and Joule's law. In 1851 Helmholtz treated the induction in branched circuits. Finally Faraday's 'electrotonic state' was mathematically interpreted thirty years later, by Maxwell, and to-day, under the name of electromagnetic momentum, it is being translated into the notation of the electronic theory.

Many physicists following the fundamental equation of Neumann (1845, 1847) have developed the treatment of mutual and self induction with special reference to experimental measurement.

On the practical side the magneto-inductor may be traced back to d'al Negro (1832) and to Pixii (1832). The tremendous development of induction electric machinery which followed the introduction of Siemens's (1857) armature can only be instanced. In 1867 Siemens, improving upon Wilde (1866), designed electric generators without permanent magnets. Pacinotti (1860) and later Gramme (1871) invented the ring armature, while von Hefner-Alteneck (1872) and others improved the drum armature. Thereafter further progress was rapid.

It took a different direction in connec-

tion with the Ferraris (1888) motor by the development of the induction coil of the laboratory (Faraday, 1831; Neef, 1839; Ruhmkoff, 1853) into the transformer (Gaulard and Gibbs, 1882–84) of the arts. Among special apparatus Hughes (1879) contributed the induction balance and Tesla (1891) the high frequency transformer. The Elihu Thompson effect (1887) has also been variously used.

In 1860 Reiss devised a telephone in a form, however, not at once capable of practical development. Bell in 1875 invented a different instrument which needed only the microphone (1878) of Hughes and others to introduce it permanently into the arts. Of particular importance in its bearing on telegraphy, long associated with the names of Gauss and Weber (1833) or practically with Morse and Vail (1837), is the theory of conduction with distributed capacity and inductance established by Kelvin (1856) and extended by Kirchhoff (1857). The working success of the Atlantic cable demonstrated the acumen of the guiding physicist.

ELECTRIC OSCILLATION.

The subject of electric oscillation announced in a remarkable paper of Henry in 1842 and threshed out in its main features by Kelvin in 1856, followed by Kirchhoff's treatment of the transmission of oscillations along a wire (1857), has become of discriminating importance between Maxwell's theory of the electric field and the other equally profound theories of an earlier date. These crucial experiments contributed by Hertz (1887, et seq.) showed that electromagnetic waves move with the velocity of light, and like it are capable of being reflected, refracted, brought to interference and polarized. A year later Hertz (1888) worked out the distribution of the vectors in the space surrounding the oscillatory source. Lecher (1890) using an ingenious device of parallel wires, Blondlot (1891) with a special oscillator, and with greater accuracy Trowbridge and Duane (1895) and Saunders (1896), further identified the velocity of the electric wave with that of the wave of light. Simultaneously the reasons for the discrepancies in the strikingly original method for the velocity of electricity due to Wheatstone (1834), and the American and other longitude observations (Walker, 1894; Mitchell, 1850; Gould, 1851), became apparent, though the nature of the difficulties had already appeared in the work of Fizeau and Gounelle (1850).

Some doubt was thrown on the details of Hertz's results by Sarasin and de la Rive's phenomenon of multiple resonance (1890), but this was soon explained away as the necessary result of the occurrence of damped oscillations by Poincaré (1891), by Bjerknes (1891) and others. J. J. Thomson (1891), contributed interesting results for electrodeless discharges, and on the value of the dielectric constant for slow oscillations (1889); Boltzmann (1893) examined the interferences due to thin plates; but it is hardly practicable to summarize the voluminous history of the subject. On the practical side, we are to-day witnessing the astoundingly rapid growth of Hertzian wave wireless telegraphy, due to the successive inventions of Branly (1890, 1891), Popoff, Braun (1899) and the engineering prowess of Marconi. In 1901 these efforts were crowned by the incredible feat of Marconi's first message from Poldhu to Cape Breton, placing the old world within electric earshot of the new.

Maxwell's equations of the electromagnetic field were put forward as early as 1864, but the whole subject is presented in its broadest relations in his famous treatise of 1873. The fundamental feature of Maxwell's work is the recognition of the displacement current, a conception by

which Maxwell was able to annex the phenomena of light to electricity. The methods by which Maxwell arrived at his great discoveries are not generally admitted as logically binding. Most physicists prefer to regard them as an invaluable possession as yet unliquidated in logical coin; but of the truth of his equations there is no doubt. Maxwell's theory has been frequently expounded by other great thinkers, by Rayleigh (1881), by Poincaré (1890), by Boltzmann (1890), by Heaviside (1889), by Hertz (1890), by Lorentz and others. Hertz and Heaviside, in particular, have condensed the equations into the symmetrical form now commonly used. Poynting (1884) contributed his remarkable theorem on the energy path.

Prior to 1870 the famous law of Weber (1846) had gained wide recognition, containing as it did Coulomb's law, Ampère's law, Laplace's law, Neumann's law of induction, the conditions of electric oscillation and of electric convection. Every phenomenon in electricity was deducible from it compatibly with the doctrine of the conservation of energy. Clausius (1878), moreover, by a logical effort of extraordinary vigor established a similar law. Moreover, the early confirmation of Maxwell's theory in terms of the dielectric constant and refractive index of the medium was complex and partial. Rowland's (1876, 1889) famous experiment of electric convection, which has recently been repeatedly verified by Pender and Cremieu and others, though deduced from Maxwell's theory, is not incompatible with Weber's view. Again the ratio between the electrostatic and the electromagnetic system of units, repeatedly determined from the early measurement of Maxwell (1868) to the recent elaborate determinations of Abraham (1892) and Margaret Maltby (1897), with an ever closer approach to the velocity of light, was at its inception one of the great original feats of measurement of Weber himself associated with Kohlrausch (1856). The older theories, however, are based on the so-called action at a distance or on the instantaneous transmission of electromagnetic force. Maxwell's equations, while equally universal with the preceding, predicate not merely a finite time of transmission, but transmission at the rate of the velocity of light. The triumph of this prediction in the work of Hertz has left no further room for reasonable discrimination.

As a consequence of the resulting enthusiasm, perhaps, there has been but little reference in recent years to the great investigation of Helmholtz (1870, 1874), which includes Maxwell's equations as a special case; nor to his later deduction (1886, 1893) of Hertz's equations from the principle of least action. Nevertheless, Helmholtz's electromagnetic potential is deduced rigorously from fundamental principles and contains, as Duhem (1901) showed, the electromagnetic theory of light.

Maxwell's own vortex theory of physical lines of force (1861, 1862) probably suggested his equations. In recent years, however, the efforts to deduce them directly from apparently simpler properties of a continuous medium, as for instance from its ideal elastics, or again from a specialized ether, have not been infrequent. Kelvin (1890) with his quasi-rigid ether, Boltzmann (1893), Sommerfeld (1892) and others have worked efficiently in this direction. On the other hand, J. J. Thomson (1891, et seq.), with remarkable intuition, affirms the concrete physical existence of Faraday tubes of force, and from this hypothesis reaches many of his brilliant predictions on the nature of matter.

As a final commentary on all these divers interpretations, the important dictum of

Poincaré should not be forgotten: If, says Poincaré, compatibly with the principle of the conservation of energy and of least action, any single ether mechanism is a possibility, there must at the same time be an infinity of others.

THE ELECTRONIC THEORY.

The splendid triumph of the electronic theory is quite of recent date, although Davy discovered the electric arc in 1821 and although many experiments were made on the conduction of gases by Faraday (1838), Riess, Gassiot (1858, et seq.) and others. The marvelous progress which the subject has made begins with the observations of the properties of the cathode ray by Plücker and Hittorf (1868), brilliantly substantiated and extended later by Crookes (1879). Hertz (1892) and more specifically Lenard (1894) observed the passage of the cathode rays into the atmosphere. Perrin (1895) showed them to be negatively charged, Röntgen (1895) shattered them against a solid obstacle generating the X-ray. Goldstein (1886) discovered the anodal rays.

Schuster's (1890) original determination of the charge carried by the ion per gram was soon followed by others utilizing both the electrostatic and the magnetic deviation of the cathode torrent and by Lorentz (1895) using the Zeeman effect. J. J. Thomson (1898) succeeded in measuring the charge per corpuscle and its mass, and the velocities following Thomson (1897) and Wiechert (1899), are known under most varied conditions.

But all this rapid advance, remarkable in itself, became startlingly so when viewed correlatively with the new phenomena of radioactivity, discovered by Becquerel (1896), wonderfully developed by M. and Madame Curie (1898, et seq.), by J. J. Thomson and his pupils, particularly by Rutherford (1899, et seq.). From the Curies came radium (1898) and the thermal effect of radioactivity (1903), from Thomson much of the philosophical prevision which revealed the lines of simplicity and order in a bewildering chaos of facts, and from Rutherford the brilliant demonstration of atomic disintegration (1903) which has become the immediate trust of the twentieth century. Even if the ultimate significance of such profound researches as Larmor's (1891) 'Ether and Matter' can not yet be discerned, the evidences of the transmutation of matter are assured, and it is with these that the century will immediately have to reckon.

The physical manifestations accompanying the breakdown of atomic structure, astoundingly varied as these prove to be, assume fundamental importance when it appears that the ultimate issue involved is nothing less than a complete reconstruction of dynamics on an electromagnetic basis. It is now confidently affirmed that the mass of the electron is wholly of the nature of electromagnetic inertia, and hence, as Abraham (1902), utilizing Kaufmann's data (1902) on the increase of electromagnetic mass with the velocity of the corpuscle, has shown, the Lagrangian equations of motion may be recast in an electromagnetic form. This profound question has been approached independently by two lines of argument, one beginning with Heaviside (1889), who seems to have been the first to compute the magnetic energy of the electron, J. J. Thomson (1891, 1893), Morton (1896), Searle (1896), Sutherland (1899); the other with H. A. Lorentz (1895), Wiechert (1898, 1899), Des Coudres (1900), Drude (1900), Poincaré (1900), Kaufmann (1901), Abraham (1902). Not only does this new electronic tendency in physics give an acceptable account of heat, light, the X-ray, etc., but of the Lagrangian function and of Newton's laws.

Thus it appears even in the present necessarily superficial summary of the progress of physics within one hundred years, that, curiously enough, just as the nineteenth century began with dynamics and closed with electricity, so the twentieth century begins anew with dynamics to reach a goal the magnitude of which the human mind can only await with awe. If no Lagrange stands toweringly at the threshold of the era now fully begun, superior workmen abound in continually increasing numbers, endowed with insight, adroitness, audacity and resources, in a way far transcending the early visions of the wonderful century which has just closed.

CARL BARUS.

BROWN UNIVERSITY.

SCIENTIFIC BOOKS.

Civil Engineering, A Text-book for a Short Course. By Lieut.-Col. G. J. FIEBERGER, U. S. Army, Professor of Engineering, U. S. Military Academy, M. Am. Soc. C. E.

It is not easy to rate the book under discussion at its true value. The tendency of engineering education of the present day is towards elaborate presentation of the several phases of engineering practise and if there is any reaction from the excessive development of so-called specialties, it shows itself in a greater concentration on elementary mechanics and other fundamentals.

When engineering education was in its infancy and when the science was being formulated, Rankine, in his famous and classic book, developed and put together all that was known on the subject. Since then, the science and knowledge of engineering have grown so rapidly and extensively that, in spite of a generous appreciation of the work of Rankine, one is startled at a present-day attempt to compress modern engineering knowledge into a single volume of less than six hundred pages.

The author explains that the book is intended to give the military cadets, who have to master many sciences and languages as well as military science and tactics, an elementary knowledge of civil engineering. To properly rate the value of the book, for its avowed purpose, this condition must be kept in mind and any comparison with other separate volumes, used in technical schools, must be carefully avoided.

About one third of the book is devoted to the mechanics of materials, and all ordinary problems of strength in flexure, tension, compression and torsion are given. Fifty numerical problems, about one to every four pages, are given to fix the principles stated, and additional illustrative problems are said to be used in the class room.

Thirty-four pages are given to hydraulics and seventy pages to bridge stresses, making one half of the book devoted to fundamental theory. While this theory is admirably presented, the principles and hypotheses carefully stated, however condensed, the writer can not help feeling that the average student mind is too immature to successfully assimilate such highly concentrated food, and further, he believes that much fundamental theory has been omitted. For example, in hydraulics no problems involving the time of emptying locks or reservoirs are given, no formulæ for velocity of approach for weirs and no discussion of submerged weirs. Yet space is taken for full algebraic development of equations of moment for continuous beams over four and even five supports.

Materials of construction, stone, cement, steel, iron, etc., are discussed to the extent of sixty pages. It is surprising, in view of the thousands of tons of Bessemer steel used annually in buildings, to read that 'open hearth steel is preferred by engineers for structural work,' while 'Bessemer steel is largely used for steel railway rails,' and further that 'cast-iron struts in the form of hollow columns are employed in structures not subjected to the shocks of suddenly applied loads.' In the description of brick, but ten lines are devoted to paving brick and the young officers are there told that paving brick are tested in a rattler used for castings or by dropping the brick repeatedly on a hard floor. It would have required so few additional lines to have

given the dimensions of the standard rattler, the standard charge and the percentage loss of good approved brick, that the omission seems strange.

The second half of the book is devoted to engineering construction proper, to foundations, the discussion of which is particularly good, to bridges (thirty-nine pages), to highways, to water supply and sewerage. These subjects are necessarily but briefly taken up and probably no two educators, in carrying out the difficult task of presenting only the essentials, would agree on what should be excluded. It is, therefore, futile to compare these chapters with those of other authors or to weigh the values of the separate paragraphs of the present book. The lists of text-books given at the end of each chapter serve to refer the young officers, at need, to the proper sources of information and are a most important part of the book. H. N. Ogden.

Cornell University.

Morphology and Anthropology, a Handbook for Students. By W. L. H. Duckworth, M.A., University Lecturer on Physical Anthropology, etc. Cambridge, at the University Press, 1904. The Macmillan Company. $4.50 net.

This is a very good hand-book for the use of students, containing a great deal in moderate compass. It makes little pretense to be anything more than a compilation, except in so far as the author gives us the benefit of his own judgment on disputed points. To present a compilation so as to be most available is a task of more than average difficulty. We think the author has in this been very successful. He first considers man's position in the animal series in the light of comparative anatomy; which implies a general review of the anatomy of the primates. Special attention is devoted to certain parts, especially the skull and the teeth. The presentation of the various views concerning the latter is particularly interesting.

We quote the words with which the second section of the book opens as the simplest way of showing the author's plan:

> The foregoing chapters have as their aim the demonstration of the fact that man is associated in a natural zoological classification with certain other mammals of the order Primates. It is now suitable to take up the second subject proposed for consideration in these notes, and to endeavor to ascertain something of man's ancestral history, that is, of the path of evolution traced by man. The means available for carrying out this enquiry are, in the present day, threefold: (1) Embryology, (2) comparative morphology of the various human races, and (3) paleontology.

The book then continues on these lines. The author introduces the embryological portion with the remark that its importance depends on the generalization that ontology repeats phylogeny. Since this book appeared this generalization has received a severe blow by Bardeen's researches on the development of the human spine, and, indeed, the author is ready to point out facts which do not agree with it. Long ago Marshall remarked that the record was a very imperfect one. It may now be questioned whether it will serve even as a working hypothesis. Be this as it may, Duckworth's observations strike us in the main very favorably, as both candid and judicious. It is not necessary to follow his work in detail.

We have purposely avoided the section on variations, not because we do not like it, but because the discussion would carry us too far. We will say in passing that the author does not seem to have freed himself from the widespread error, fostered by writers of the class of Wiedersheim and Testut, that resemblance is evidence of relationship. This slipshod method of thought has been so long condoned by those who should have been outspoken that it is doubly pleasant to read Osborn's address on the 'Present Problems of Paleontology.' Though our present author does not seem, as we have said, to have freed himself from this delusion, yet one suspects that he does not feel quite comfortable in its meshes. The reader will find in this part of the book a very convenient account of many methods used in practical anthropology.

A considerable part of the division of paleontology is given to the discussion of the

Trinil remains. This is very interesting. The author gives us the names of the three groups of anatomists who consider the remains human, simian and intermediate, respectively. The first group is essentially English, the second German and the third composite. Duckworth joins the last group, though admitting that the femur may be human. It is unfortunate that, having given so much space to this interesting question, he has not discussed the evidence that the pieces belong to one individual.

There are many other points which it would be interesting, at least to your reviewer, to discuss at length; but enough has probably been said to show that in his opinion it is a very good and useful hand-book.

T. D.

SCIENTIFIC JOURNALS AND ARTICLES.

The September issue of the *Journal of Comparative Neurology and Psychology* contains the following articles: 'A Study of the Functions of Different Parts of the Frog's Brain,' by Wilhelm Loeser. The brain was experimentally examined by the extirpation of various regions (twenty-two operations) and study of the deficiency phenomena and other symptoms. 'The Central Gustatory Paths in the Brains of Bony Fishes,' by C. Judson Herrick. This paper (which was awarded the Cartwright prize for this year) is a continuation of the author's previous studies on nerve components, in course of which the peripheral gustatory system has been isolated and experimentally studied in fishes. Selecting the types in which this system attains its maximum development, the central gustatory paths are demonstrated by various microscopical methods, the research including a description, accompanied by forty figures, of the conduction paths for all of the important gustatory reactions which have been experimentally observed in the normal life of these fishes. The central gustatory centers are found to be more closely related to the central olfactory system than to any other part of the brain.

Professor Frank Smith, of the University of Illinois, has been made zoological editor of *School Science and Mathematics*. The biological section, of which Professor Caldwell was formerly editor, has been divided into two sections, a zoological section and a botanical section. Professor Caldwell remains the botanical editor.

DISCUSSION AND CORRESPONDENCE.

THE LETTER K IN ZOOLOGICAL NOMENCLATURE.

There are some influential zoologists who, in their zeal for the integrity of scientific Latin (or Neolatin), propose to change the letters k and w, wherever they occur, into c and v. Thus Sir G. F. Hampson, in his great work on the moths of the world, cites a species as *Episilia voccei*, the specific name being a new rendering of *wockei*, originally proposed by Moeschler. Unfortunately, this method results in some unexpected duplication of names. Thus Gray, in 1846, applied the generic name *Kogia* to the pygmy sperm whale. Butler, in 1870, used *Cogia* for a valid genus of butterflies, which is recognized to-day by Dr. Dyar as occurring in our own fauna. Now Dr. D. G. Elliot, in a recent work, amends the name of the whale to *Cogia*, and if this is accepted the name of the butterfly-genus must fall. It is true that Elliot's *Cogia* is later than Butler's, but it is proposed as the correct way of spelling Gray's genus, and not intended in any sense as a new name.

Theobald has lately proposed *Cellia* as the name of a genus of mosquitoes. But in 1822 Turton named a valid genus of mollusca *Kellia*. According to the Hampson-Elliot method this becomes *Cellia*, and the mosquito-genus name is a homonym.

Kallima was proposed by Westwood in 1850 as the name of a well-known genus of butterflies. In 1860 Clemens named a valid genus of moths *Callima*. Now Dr. Dyar, because of *Kallima*, has named the moth genus *Epicallima*.

Again, *Cnephasia*, Curtis, interferes with *Knephasia*, Tepper.

A curious case occurs in a genus of African moths, *Xanthospilopteryx*. In 1893 Carpenter named a species *X. kirbyi*, but it is a synonym of *pardalina*, Walker. In 1897 Holland

named another *X. kirbyi,* but this is a homonym, as the rules are generally understood. Hampson calls Holland's species *X. cirbyi,* and it is imaginable that this might be interpreted as the necessary new name for the insect. Since, however, it is only intended as a new way of writing the old name, it seems that Holland's insect should be renamed, say, *X. hollandi.*

Enough has been said to show that the proposed abandonment of k and w, if it is not to prevail, should be checked as soon as possible; or if it is to be the rule, should be widely known, so that proposers of new names may guide themselves accordingly. Personally, I am totally opposed to it, on the ground that names are merely symbols designating particular objects, and the most we can ask is that they have a Latinoid ending, and are not too long. Nevertheless, the matter is at present an open one, and if most zoologists prefer to follow Hampson and Elliot, the minority will probably give in to their wishes, for the sake of uniformity. On the other hand, if nearly all are against the proposal, it would seem that a few should not persist in making such changes as those cited, unless they can convince themselves that a very important matter of principle is involved.

If the editor will allow it, I will herewith ask all working zoologists who are willing to take the trouble to send me a post-card voting for or against the substitution of c and v for k and w, and I will list the names and send them for publication in SCIENCE. I think that the names should be published, for several rather obvious reasons, not the mere numbers pro and con.

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'HAMMOCK,' 'HOMMOCK' OR 'HUMMOCK'?

SOME recent botanical papers seem to indicate that there is still some uncertainty as to which of the above is the proper designation for a certain class of geographical features of frequent occurrence in some parts of the southeastern United States. These three words may represent three totally different and independent ideas, but they are so similar in spelling that one may be easily transformed into another by a mere typographical error. But typographical errors will not account for all cases, and there are certain other circumstances which complicate the problem. Having given the matter considerable study lately, both in field and library, I can present some observations which should clear up most of the existing confusion.

The lexicographers all seem to favor 'hummock.' Webster, for instance, says: "Hummock (probably an Indian word). (1) A rounded knoll or hillock; * * * (2) A ridge or pile of ice * * *. See Hommock. (3) Timbered land. (Florida.)" Under 'hommock' is the following definition: "Hommock (written also hammock and hummock). (Probably an Indian word.) A hillock, or small eminence of a conical form, sometimes covered with trees. *Bartram.*" The definitions in the Century and Standard dictionaries are somewhat longer, but do not differ materially from that of Webster, except that they say that hummock is probably a diminutive of hump. In all three, Bartram is the only authority cited for 'hommock'; and this word occurs on pages 31, 219–221, and perhaps elsewhere in the 1794 edition of his 'Travels.' The same spelling is used throughout Dr. E. W. Hilgard's 'Report on the Geology and Agriculture of Mississippi,' published in 1860, and in that work several varieties of 'hommocks' are fully described. Dr. Hilgrade in a recent letter informs me that that spelling was in accordance with the pronunciation used by the natives, but that he now believes 'hammock' to be correct, and writes it that way.

The published references to 'hammock' and 'hummock' are so numerous that it would be impracticable to attempt to list them; but thus far I have noted the former in at least thirty different books and papers, the earliest dating back to 1839, and the latter in about half as many, beginning with 1834. Most of the occurrences of both forms are in works dealing with Florida, and a careful search through Florida literature would doubtless reveal many other cases of each. It is

very significant in this connection that most of the writers who use 'hammock' have spent much more time in the regions they describe than have those who use 'hummock'; also that some who preferred the latter have expressly stated that the natives always pronounced it 'hammock,' and yet their faith in the dictionaries seems to have been too firm to be shaken by this indisputable evidence. In some cases it is almost certain that 'hummock' was put in by the editor or printer, without the sanction of the author,[1] though I have indeed noticed one or two cases where the same may be said of 'hammock.'

As far as my experience in the field goes, the natives in Georgia invariably say 'hammock.' I have heard this word in the counties of Chatham, Coffee, Lowndes, Pulaski, Tattnall and Wilcox, and it is doubtless used throughout the intervening ones. If any further evidence were needed, a good map will show a Gulf Hammock (also a post-office of that name) and a Hammock Creek in Florida, and a Hammock Island in Georgia. I have never yet seen 'hummock' on a map though, nor found any evidence that it is ever used in conversation anywhere (in the sense here indicated). As usage fixes the language, it follows that 'hammock' is the correct form.

Now as for the definition of this word. It is used for quite a variety of conditions, but from all the evidence obtainable it may be defined broadly as a limited area, with comparatively dry soil (at least never inundated, and thus distinguished from a swamp), containing a large proportion of trees other than pines, and located in a region where 'prairies,' marshes or open pine forests predominate. Topographically a hammock may be either a slight elevation, or a depression, or a slope, and its soil may be sandy, clayey or rocky. The soil is usually rather rich, and the trees growing in it are usually mostly evergreens—though there is probably no one tree which characterizes all hammocks—and they usually grow so close together as to shade the ground and allow the formation of humus, which is almost wanting in adjacent areas.

A few varieties of hammocks may be briefly mentioned. On the coast of South Carolina and Georgia, at least in the vicinity of Savannah, a hammock is a low sandy island in a salt marsh, conspicuous for its dense growth of evergreen woody plants; and in the Everglades of Florida, according to the accounts of several different explorers, it is a sort of rocky oasis, elevated a few inches above the adjacent prairies, and densely wooded. For these two kinds of places the term 'hummock' (diminutive of hump) would not be altogether inappropriate, and this fact doubtless accounts for some of the confusion above mentioned. But in central Florida, by all accounts, it seems that a hammock is usually a depression; while in the interior of the coastal plain of Georgia it is nearly always a sandy slope forming an intermediate zone between the river or creek swamps and the sand-hills which border them.

The published references to the subject show hammocks to range from North Carolina to Florida and Mississippi,[2] and, like many other interesting things, they seem to be strictly confined to the coastal plain. The natives of other parts of the country seem to have no knowledge of such a word, and as no lexicographers, and few writers of any kind, live in the regions where hammocks occur, it is not surprising that this word should be incorrectly treated in all dictionaries.

As for the etymology of 'hammock' (in this geographical sense) I have no suggestions to offer, other than that given by Webster for 'hommock' and 'hummock.' As a hammock as here defined is always characterized by its vegetation rather than by its topography, it can hardly have anything to do with 'hum-

[1] A case of this kind has occurred in the columns of SCIENCE since the above lines were written and sent to the editor. In the issue of June 16, in the report of a paper I read before the Torrey Botanical Club in April, I am made to say 'hummocks' instead of 'hammocks.'

[2] In a paper published by Dr. Arthur Hollick about twenty-five years ago (*Bull. Torr. Bot. Club*, 7: 14, 1880) there is a reference to a 'hammock of soapstone and iron ore' on Staten Island, which looks like a surprising extension of range; but Dr. Hollick tells me that 'hummock' is what he intended to say.

mock,' if that is a diminutive of hump, as seems most likely. Whether there is any connection between our hammock and 'hammock' in the ordinary sense (German *Hangematte*) perhaps some philologist can tell us. If 'hommock' could be universally adopted by the natives of the southeastern coastal plain, then 'hammock' could be restricted to the familiar manufactured article and 'hummock' to a heap of ice or something of that sort; but this is obviously out of the question at present.

Before dismissing the subject I should like to suggest to those botanists who believe in giving names of classical derivation to every kind of plant-habitat, that they find a Latin or Greek equivalent for the word under discussion, and thus do away with all this uncertainty at one stroke, at least as far as botanists are concerned.

ROLAND M. HARPER.

COLLEGE POINT, NEW YORK,
June, 1905.

INDIAN BONE COMBS.

TO THE EDITOR OF SCIENCE: Some of your readers may receive the valuable archeological reports of David Boyle, of Toronto, annually made to the minister of education, Ontario. Mr. Boyle fully believes that the bone combs found on Indian sites in Canada and New York are a purely aboriginal idea, while I as firmly hold that this idea came from Europeans. Such differences are common and natural, but the report for 1904 mistakes my position saying:

> The contention of Dr. Beauchamp is simply this, that without metallic tools it was impossible to make a comb, and the inference is that before the appearance of Europeans, the Indians had no use for any article of this kind.

The latter statement is correct, the former an error of my valued friend. If I have made such a statement I gladly retract it. I certainly do not believe this impossible in a general way, but metallic tools were used in most cases.

I have figures of forty-five of these combs from Iroquois sites in New York and they are found there on no others as yet. Ten of these are from Mohawk sites, found with glass and brass ornaments, and there are others there. Four are from Cayuga sites of similar character. Onondaga sites have furnished seven, of which two are as early as 1600. Seneca sites have furnished twenty, mostly made about 1687, with two more which are in a sense prehistoric. Some recent ones have not been figured. From Oneida sites I remember none, though they should occur there. Two others were from Jefferson County, where they are certainly rare. One of these may be classed as early and the other recent. Some brass beads found on sites there now place these in the sixteenth century, as had been surmised. Of those enumerated forty were found with European articles, and five may be dated anywhere from 1550 to 1600. The earlier and ruder ones were made with stone tools; the more elaborate with metallic implements. The soundness of my position will thus be seen. All known New York combs of this character seem to have been made between 1550 and 1700, and may be ascribed to European contact. A few were made with stone tools, soon replaced with those of metal, and I certainly do not think it was impossible to have made the ruder forms without the later tools. Why the Indians did not think of these combs before we can not tell. It is evident they did not till after European contact.

Some of the later combs are fine in design, and Mr. Boyle has given some figures of Egyptian bone combs, furnished by Wm. Flinders Petrie, and there are curious resemblances to those found in New York and Canada, so many centuries later. One great value of Mr. Boyle's reports to those laboring in New York is in the close relations of the fields, so well shown in his long and accurate work.

W. M. BEAUCHAMP.

SYRACUSE, N. Y.,
August 11, 1905.

SPECIAL ARTICLES.

THE SYSTEMATIC NAME OF THE JAPANESE DEER.

THAT an author himself has no more right to change a systematic name once given by him than any other person is a principle now

accepted by all codes of zoological nomenclature.

In a preliminary introduction to the Fauna japonica entitled 'Coup d'œil sur la faune des îles de la Sonde et de l'empire du Japon,' published in 1837, and issued in the fourth fascicule of the work, which also contained the Japanese snakes, Temminck briefly diagnosed the Japanese deer, on p. xxii, as a new species under the name of *Cervus nippon*. In 1844, seven years later, in the second decade of the mammals of the same work, a plate illustrating this deer was published as *Cervus sika*. The text describing it more in detail under the latter name did not appear until many years later, probably not until 1852 or 1853. The diagnostic features given are essentially the same as indicated in the preliminary discourse of 1837.

The Japanese deer must, therefore, in the future stand as *Cervus nippon* Temminck.

LEONHARD STEJNEGER.

U. S. NATIONAL MUSEUM,
September 7, 1905.

THE POSSIBILITY OF ABSORPTION BY HUMAN BEINGS OF NITROGEN FROM THE ATMOSPHERE.

THE physiological value of nitrogen is to provide the staging or framework for the support and functional efficiency of the construction and nutritive processes at work in the living animal organism. The absorption of nitrogen by the animal organism has lately been regarded as resulting from the intermediary action of the vegetable world—a mode of nature-economy which there would be no reason for limiting to compounds of nitrogen, but should be extended to the entire range of animal-mineral absorption.

From this point of view, which seems to be based on close scientific observation, there has lately been extended a good deal of apparently well-qualified criticism with regard to the efficacy of the animal body-tissue to absorb and assimilate drugs derived from the mineral kingdom. Thus the administering of iron, strychnine, arsenic and other mineral tonics has been vigorously and justly condemned, not only by lay students, but also by the more advanced students in the medical profession themselves.

Yet, in the light of still more recent researches, it has been ascertained that the true reason for condemning certain drug medication does not lie in the assumed failure of the mineral compound to yield to absorption, but rather in the fact that such absorption is really possible. For, while the power of the mineral to generate changes in the animal organism largely proceeds on a mechanical basis, the fact remains that the changes wrought, let us say, by arsenic in the hemoglobin of the blood can be rationally explained only by admitting an action due to processes of physiological chemistry.

To discover the character of the forces and conditions at work in these processes of absorption has recently been the aim of some eminent French and German scientists. Thus, in his extensive studies of the character and genesis of nitrifying bacteria, Dr. Wohltman, of the Agricultural Institute in Bonn-Popelsdorff, Germany, has brought to light some highly interesting points with regard to the relations existing between nitrogenous compounds and organic substances. Among other observations he has found that the action of certain bacteria, hitherto considered indispensable in the elaboration of the nitrogen molecule for its absorption by the vegetable, is so only under certain conditions. In his 300 experiments with the soil in the valley of the Rhine, Dr. Wohltman ascertained that wherever the soil is rich in nitrogenous fertilizers, preferably ammonium nitrate, the leguminous plants are found to grow and absorb nitrogen without the presence of bacteria. From this fact Dr. Wohltman draws the conclusion that the 'association of the plants with the bacteria is not a necessity, but an expedient, and whenever there is a rich supply of nitrogenous elements in the soil, they (the plants) dispense with the bacteria and with the free nitrogen, which the latter make available, by directly secreting it from the chemical combination of soil or air in which it is held suspended.'

From this fact, it would certainly be justifiable to draw the inference, that whatever

under given conditions is available to the vegetable organism, may also, under corresponding conditions, be within the power of the animal organism. And as the intermediary action of the bacteria has its basis in 'expediency' rather than in necessity, it follows that nature can dispense with any process, when ends of higher evolutionary order are aimed at. Hence, she recognizes no immutably fixed ways of procedure, but manifests everywhere along the lines of least resistance, using methods which, for the time being, conform closest to the most advantageous conditions. Nor are there to be found any organically or physiologically interposed impassable barriers between the various kingdoms of nature. Therefore, if the animal kingdom is evolved from the vegetable, there can be no power of function or assimilation in the latter, which is not also present—though perhaps latent—in the former. The larger must necessarily in itself contain the lesser, as a function or equality, once evolved, is forever retained in the subsequent output of a similar evolution; while at the same time continually increasing in strength and complexity. Hence, whenever 'expediency' demands the functioning in an entity of a certain power, the latter will make its appearance on the field of evolution though conditioned by natural environments.

Through his painstaking experiments, Dr. Wohltman has shown that in the absence of the specific bacteria, the plant organism has proceeded to exercise unsuspected functional powers. That similar powers, under corresponding conditions, may be called into action in the animal organism, can not reasonably be doubted, and the absence of 'free nitrogen' in the animal system, *i. e.*, the reduction of nitrogenous tissue caused by a longer or shorter abstinence from food, may probably bring about such conditions. Of course, on the other hand, the circumstance must not be lost sight of that, even if the proper conditions have been present, the evolution of the great majority of individuals may not yet have reached a stage of development where the inherent powers of their nature are adequate to an immediate response to the call. Hence, the utilization of this great physiological fact must be preceded by a self-conscious recognition and appreciation of the evolutionary possibility of the process. That in course of physical and mental unfoldment, the individual shall be able to absorb his nitrogenous needs directly from the atmospheric air, we have, in view of the above facts, no true reason for doubting.

In the journey through natural evolution we are met by neither air-tight nor life-tight compartments. To their origin and essence all forms are identical; and a rising French scientist, Dr. Barière of Lyons, has arrived at the position that this identity of the entities of evolution extends not only to the character of origin, but also to the place of origin. According to him, the cradle in which life found its first receptacle was rocked by the waves of the ocean, or, in the words of the old account of Genesis which the doctor quotes—not in support of, but as a case of curious coincidence with, his theory: "The spirit of God moved upon the face of the waters." "It" (the primitive life), Dr. Barière continues, "sprang from the single cell, which constitutes practically the same manifestation of forces to-day as in a hypothetical dawn of existence. And in the bodies of all plants and animals the cells are continually bathed in a fluid, which, whether lymph, blood, or vegetable sap, differs in no essential way in its composition from sea water."

But more than this, the crystal itself has yielded up its secret to the scrutinous search of science, and confessed to a possession of the same powers of absorption as found in the kingdoms above it. At the special stage in the formation of crystals when they are found to collect themselves from their saline solutions into concrete substance, they seem to behave like sentient beings, governed in their movements by orderly purposes. In this intermediate stage between solution and crystalline fixity they exhibit all the characteristics of complete cell life, with cell-wall, nucleus, nucleoli and granulated cell body, while all throughout the transformation they show a very marked self-adjusting activity.

This fact would make it appear very prob-

able that the genesis of the single cell, whether passing into crystalline fixity or organizing into higher forms of life, points to the same place of origin—the salt sea—where the microscopic entity at the very outset is surrounded by large quantities of organic nitrates. Hence, the power of absorbing nitrogen would constitute the first and mutual condition for any order of cellular existence, organic or crystalline. And, as the evolution of the organic structure proceeds through and by the inorganic, it follows that the native powers of the mineral cell—of which nitrogenous absorption constitutes one—are all transmitted to the subsequent cell structures of vegetable and animal life.

On the basis of the experiments and investigations referred to in this article, there seems to be nothing either unreasonable or unscientific in the theory that the human being, under certain conditions, possesses the power of assimilating nitrogenous compounds in his vital economy without the assistance of an intervening vegetable kingdom.

AXEL EMIL GIBSON.

LOS ANGELES, CAL.

QUOTATIONS.

MR. J. B. BURKE'S EXPERIMENTS.

MR. BURKE made use of solid radium bromide in fine powder. He sprinkled a few minute grains on a gelatine broth medium, possibly somewhat soft, so that the granules would sink slowly below the surface. Once there they would dissolve in and decompose the water, liberating oxygen and hydrogen, together with emanations, which would remain mixed with these gases. The gases would form minute bubbles, probably of microscopic dimensions, and the coagulating action of the emanation on the albumen of the liquor would surround each with a skin, so that the product would appear like a cell; its contents, however, would be gas, or, rather, a mixture of the gases oxygen and hydrogen. The emanation, enclosed in such a sack, would still decompose water, for enough would diffuse through the walls of the sack, which, moreover, would naturally be moist. The accumulation of more gas would almost certainly burst the walls of the cell, and almost equally certainly in one or two places. Through the cracks more gas would issue, carrying with it the emanation, and with it the property of coagulating the walls of a fresh cell. The result of the original bubble would resemble a yeast cell, and the second cell a bud, or perhaps more than one, if the original cell happened to burst. This process would necessarily be repeated as long as the radium continued to evolve emanation, which would be for the best part of a thousand years. The 'life,' therefore, would be a long one, and the 'budding' would impress itself on an observer as equally continuous with that of a living organism.

I am surprised to learn from Mr. Burke's first letter that the 'organisms' appear to dissolve in water. The emanation does not coagulate or apparently affect gelatine, for I have tried and found that it does not; indeed, it was not to be expected. Is it possible that the gelatine is pushed away to form the cell-wall, leaving the albumen as a partial content of the cell, along with gas? The latter would, doubtless, diffuse through the cell-wall of coagulated albumen and dissolve in and mix up with the water. On placing the apparent 'organism' in water the gelatine, too, would be extracted, and the cell would seem to disappear, the wall being excessively thin. It would be interesting to learn if Mr. Burke has attempted to stain his 'organisms' with the usual dyes used by microscopists. It is possible that the coagulated albumen would take the stain better than the uncoagulated matter and that the structure would thus be revealed.

As I said before, I have no desire to dogmatize. The supposition that the pouring of energy in some form into matter similar to that of which living organisms are made, and which serves as sufficient food for actual living organisms, might conceivably result in the production of life, is a very attractive one. But one is bound to sceptical, and the explanation which I have ventured to suggest appears to me to be sufficient to meet the case. But no one will rejoice more than I if it should ultimately prove to be inadequate.—Sir William Ramsay in *The Independent*.

THE CHICAGO DEATH-RATE.

A violent difference of opinion existed in 1900 between the Chicago Health Department and the Census Bureau. The census authorities credited Chicago with a population of 1,698,753, while Chicago claimed, and estimated her death-rate on, a population nearly a quarter million greater. The census bureau said, moreover, that Chicago had made the opposite error in counting her deaths. The census enumerators turned in 1,930 deaths, which were not accounted for in the returns of the City Health Department. Thus it appeared that Chicago had made a plus error of 15 per cent. in estimating her population and a minus error of 6 per cent in counting the deaths. The Census Bureau said that the 1900 death-rate of Chicago was 16.2 per 1,000. In the very next year, 1901, Chicago published her famous low death-rate of 13.88, which, Dr. Whalen says, this year's death-rate will surpass. Of course, the death-rate for 1901 was discredited. The statement that 1901 was a remarkably healthy year throughout the world did not remove the doubt which the census results had thrown on Chicago's vital statistics. The department itself later yielded the point of population and accepted the census figures. The discrepancy in the mortality was allowed to slumber and Chicago offered no satisfactory explanation of the 1,930 death records which the enumerators turned in and which the Census Bureau added to the records furnished the Health Department of Chicago. It is well known that the census enumerators' returns of mortality are about 40 per cent. short. Since these returns are based on inquiry at every house concerning the deaths during a year preceding, the results can hardly be expected to exceed 60 per cent. of the deaths truly chargeable to the period. A comparison of the enumerators' returns in 1900 with the mortality returns furnished by the Health Department of Chicago (16,059 and 27,752) shows that the enumerators did not get quite 60 per cent. of the true returns. If, therefore, the 1,930 records appearing in the census schedules, but absent from the city returns, really belonged to Chicago's mortality for 1900, the indications are quite clear that the mortality upon which the Health Department based its death-rate was less than the true mortality by 3,216 deaths, and that Chicago was fairly chargeable with a death-rate in 1900 of 18.23 per 1,000, two points more than the census rate and about four points higher than the rate which Chicago published.

The suggestion of Dr. Whalen that New York inflates her population figures is not supported by an examination of the census reports, nor did the twelfth census indicate a short count of the New York mortality in 1900. The advantage gained by the recent census of New York (46,000 above the population estimated on the experience of the previous decade) is far too small to justify a suspicion of padding; but Dr. Whalen's suggestion that New York 'corrects' her mortality sheet by excluding all deaths of non-residents and all deaths of infants under two weeks, opens up a question of great importance in American mortality registration. There is no agreement among American registration offices as to the elements of mortality rates. The cities of this country are absolutely unanimous in the exclusion of non-resident decedents, unless Chicago counts them in. Only a few cities, however, publish statements of the non-resident mortality, and not one explains what is meant by a non-resident. It would help the cause of registration tremendously if New York would make public answer to Dr. Whalen's definite charges of unfairness, and if Chicago would also define her practise. Let us have from each city answers to the following questions: Are the deaths of non-residents, occurring in the city, included in the total mortality on which the death-rate is figured? Are the deaths of citizens, taking place outside the city, included in the death-rates? What rule determines the question of residence in cases of death within the city? What rule determines the question of residence in cases of death without the city? Is any part of the infant mortality excluded from the death-rates? Are stillbirths included in the total mortality? What definition of a stillbirth governs your registrar? —*American Medicine.*

CURRENT NOTES ON METEOROLOGY.

MONTHLY WEATHER REVIEW.

RECENT numbers of the *Monthly Weather Review* have contained articles of general interest as follows:

No. 3, 1905; 'Application of Mathematics in Meteorology,' by Professor F. H. Bigelow. Reprinted from *Bull. Phil. Soc. Wash.*, Vol. 14, 1905, p. 215. Summary of the mathematical state of certain important meteorological problems. 'The Diurnal Periods of the Barometric Pressure,' by the same author. 'Tornado in Eastern Alabama, March 20, 1905,' by F. P. Chaffee. The usual phenomena accompanied this tornado. 'The Variations in Atmospheric Transparency during 1902, 1903 and 1904,' by H. H. Kimball. A comparison of some of the results obtained in the United States and in the Pyrenees. 'Twilight Glows and Connected Phenomena observed in 1902, 1903 and 1904, in the Pyrenees,' by E. Marchand. From the *Ann. Soc. Met. de France,* February, 1905. This includes observations on the diminution of solar radiation. 'Tornado near Bluff Springs, Fla., March 20, 1905.'

No. 4, 1905: 'The Diurnal Periods of the Vapor Tension, the Electric Potential and Coefficient of Dissipation' and 'The Observations with Kites at the Blue Hill Observatory, 1897–1902,' by Professor F. H. Bigelow. 'Mathematical Theory of the Nocturnal Cooling of the Atmosphere,' by S. T. Tamura. A historical and critical survey of the problem of the nocturnal cooling of the atmosphere, and a mathematical theory of the nocturnal cooling of the atmosphere near the earth's surface. 'The Influence of Small Lakes on Local Temperature Conditions,' by James L. Bartlett. A study of the influence of Lakes Mendota and Monona, and of other smaller lakes, upon the climate of Madison, Wis. 'Wind Velocities for Different Altitudes and Exposures,' by A. J. Mitchell. Observations made at Jacksonville, Fla. The conclusion is that an increase in elevation of the anemometer cups of 50 to 60 feet results in an increase of approximately one mile per hour in the lower circulation at Jacksonville. 'Tornadoes of March 17, 1905, in Western Oklahoma,' by C. M. Strong. 'A Cold-Weather Dust Whirl,' by F. W. Proctor. A dust whirl at 11 A.M. March 13, 1905, over frozen ground, at Fairhaven, Mass. A very rare phenomenon. 'Note on the Winds of the Region adjacent to the Gulf of California,' by Professor George H. Stone. These winds come persistently from about south, and have a constancy which the author describes as monsoonal. 'A Heavy Deposit of Hoarfrost and its Effect in Retarding Nocturnal Cooling,' by D. A. Seeley. At Peoria, Ill., illustrated by a thermograph curve. A good example for use in teaching. 'Tornado of April 14, near Pensacola, Fla.,' by Wm. F. Reed, Jr. 'Meteorological Course at Williams College,' being part of a syllabus used in teaching. The course is unusually complete.

ISLANDS FOR PURPOSES OF WEATHER FORECASTING.

IN *Nature* for June 1, 1905, Dr. W. J. S. Lockyer points out the need of securing weather observations from islands to windward of the continents when possible, in order that the conditions which are approaching the lands from the sea may be known in advance. The value of wireless telegraph messages from vessels to the west of the British Isles; of reports from the West Indies to the United States; from Mauritius to India and to Africa; of Tristan d'Acunha to Africa, etc., is emphasized. It is pointed out that conditions at a great distance are important in determining seasonal weather of many countries. Thus the air current which passes the western coast of Australia in July later becomes the southeast trade of the Indian Ocean, and finally reaches India as the southwest monsoon.

METEOROLOGY AND OTHER SCIENCES.

CAPTAIN D. WILSON-BARKER, R.N.R., in his presidential address before the Royal Meteorological Society, London (*Quart. Journ. Roy. Met. Soc.*, April, 1905), spoke of 'The Connection of Meteorology with other Sciences,' pointed out that meteorology deserves much more attention than it receives, and expressed the wish that the subject might be taught in schools. 'The United States,' said Captain Wilson-Barker, 'have devoted much attention

to meteorology, with most satisfactory results.' One point in his address must commend itself to many persons who try to keep up with the progress that is being made along the various branches of meteorological science, and that is the plea for maintaining 'a comprehensive outlook on the whole field of investigation,' which is important in these days of intense specialization.

A NEW TEXT-BOOK OF METEOROLOGY.

The June number of the *National Geographic Magazine* contains an article entitled 'Forecasting the Weather and Storms,' by Professor Willis L. Moore, chief of the Weather Bureau. This article occupies all but three pages of this number. It is illustrated by means of numerous weather maps, storm charts and half-tone prints, and is to form, as we learn, one chapter in a forthcoming book by Dr. Moore, entitled 'The New Meteorology.' The author's experience in the Weather Bureau, and the exceptional facilities at his command, will doubtless result in producing a popular book which will be very widely read.

NOTES.

At a recent exhibition of meteorological instruments held under the auspices of the Royal Meteorological Society in London, one of the most interesting exhibits was a series of twenty-four-hour traces of continuous sunshine, obtained on the Antarctic expedition of the *Discovery*.

Consular Report for February, 1905, contains a report by the American consul at Nottingham, England, on the fogs of that district, their relation to commerce, business and health, and the suggestions that have been made regarding the dispelling of fogs.

A paper by Forel in the *Archives des Sciences physiques et naturelles* for March, 1905, summarizes the observations of Bishop's ring which followed the Mont Pelée eruption of May 8, 1902.

Professor Angelo Mosso (*Atti dei Lincei*, XIV., (1)), has made experiments on the effect of carbon dioxide as a remedy for mountain sickness, and recommends that about eight per cent. of CO_2 should be added to the compressed oxygen which is taken for use during high balloon ascents.

R. De C. Ward.

NOTES ON INORGANIC CHEMISTRY.

SOLUTIONS IN LIQUID AMMONIA.

The modern theories of solution are based almost exclusively upon phenomena taking place in aqueous solution. It is true that the action of other solvents, especially the organic, has been studied, as well as that of liquid ammonia, and to a lesser extent of liquid hydrogen chlorid, sulfid and fluorid. But this work has contributed little to the theory of solutions in general, nor have the theories of solution in water been to any considerable extent successfully applied to other solvents. During the past eight years Professor E. C. Franklin, now of Stanford University, has done much work on solutions in liquid ammonia, and in a recent *Journal* of the American Chemical Society he has brought forward a rather notable generalization, which brings the liquid ammonia solutions into line with water solutions. It has long been recognized that liquid ammonia stands near water as a solvent. It is an associated liquid with a fairly high dielectric constant. While inferior generally to water as a solvent, it has marked power of ionization, the more dilute ammonia solutions being even better conductors of electricity than aqueous solutions of the same concentration. As water from the standpoint of solution is to be looked upon as a compound of H ions and OH ions, so ammonia is a compound of H ions and NH_2 ions. When acids are dissolved in liquid ammonia they form, as a matter of course, ammonium salts, but nevertheless they retain true acid properties. They discharge the color of phenolphthalein; they dissolve metallic sodium and some other metals with the evolution of hydrogen and the formation of metallic salts; they dissolve certain metallic oxids and basic salts which are insoluble in the liquid ammonia. Here the acid ion seems to be not H, but NH_4, or as we may write it, $NH_3 . H$. It is, however, by no means im-

possible that in aqueous acids we have present, not the ion H, but OH_3 or $OH_2 . H$. In each case the hydrogen ion would be associated with a molecule of the solvent. Besides these compounds which act as acids in water, there are other compounds not acids in aqueous solution, which act as acids in ammonia. Such, for example, are the acid amids and imids. In acetamid we may, perhaps, assume the ions CH_3CONH and H; in urea the ions H_2NCONH and H, as well as $CO(NH)_2$ and 2H. Here the NH seems to play the same part as the oxygen atom of the hydroxyl of acetic or carbamic acid. When sodium is dissolved in liquid ammonia, it gradually decomposes it with the evolution of hydrogen and the formation of sodium amid, $NaNH_2$. The reaction is of course exactly analogous to the action of sodium on water with the formation of sodium hydroxid, NaOH. The interesting point is that sodium amid in ammonia solution is a base, just as sodium hydroxid in water. It colors phenolphthalein and neutralizes the ammonia acids. Just as aqueous bases contain the OH ion, the ammonia bases contain the NH_2 ion. When the bases react upon acids in liquid ammonia, salts are formed, which may be precipitated when insoluble, or left as crystals on evaporating the ammonia. Thus the reaction between acetamid and potassium amid may be expressed as follows:

$$CH_3CONH . H + K . NH_2 = CH_3CONH . K + NH_3.$$

Salts of the strongly positive metals, as far as they are soluble, dissolve in ammonia as in water without change. Compounds of the negative elements are more or less completely hydrolyzed by water. The same compounds are 'ammonolyzed' by liquid ammonia. The analogy is shown by comparing the reactions:

$$AsCl_3 + 3H . OH = As(OH)_3 + 3HCl$$
$$AsCl_3 + 3H . NH_2 = As(NH_2)_3 + 3HCl,$$
$$(3HCl + 3NH_3 = 3NH_4Cl).$$

As the hydrolysis of $SnCl_4$ gives us not $Sn(OH)_4$ but $SnO(OH)_2$, so the ammonolysis of PCl_3 gives not $P(NH_2)_3$ but $P(NH)NH_2$, and of SiS_2 gives $Si(NH)_2$ rather than $Si(NH_2)_4$. As with hydrolysis so in ammonolysis the reaction need not go to completion. In such a case we have in aqueous solution the precipitation of basic salts, and so here also are formed ammono-basic salts, which may be more or less de-ammoniated and hence appear as amins, imins or even as nitrils, that is, nitrids. The reaction of the formation of these basic salts is, as would be expected, reversible, and they can, after precipitation, be carried back into solution by an excess of 'ammono-acid,' that is, by an ammonium salt. This method of treatment seems to clear up very satisfactorily the mercury-ammonia compounds which have for nearly three quarters of a century been a stumbling block to chemists. They here appear to be ammono-basic salts, or mixed hydro- and ammono-basic salts, occasionally with ammonia of crystallization. They thus fall completely in line with the many and more familiar hydro-basic compounds of mercury.

It is a large field which has thus been opened by Franklin, and one which will require much work, of great experimental difficulty, before it is satisfactorily worked over, but what has been already done has served to greatly broaden our knowledge of solutions.

J. L. H.

FIRST INTERNATIONAL CONGRESS OF ANATOMISTS.[1]

THE first meeting of the Congrès féderatif international d'Anatomie was held in Geneva, and commenced on the morning of Sunday, August 6, by the opening of an exhibition of specimens and appliances illustrating recent progress in anatomy. The congress closed on the evening of Thursday, August 10, when three hundred members and adherents of the congress were entertained by the city of Geneva at an official banquet. The congress represented a conjoint meeting of the five leading anatomical societies—the Anatomical Society of Great Britain and Ireland, Anatomische Gesellschaft, Association des Anatomistes, Association of American Anatomists and the Unione Zooligica Italiana.

[1] From *Nature*.

Almost every country was represented. Switzerland itself contributed more than 100 members, France 66, Germany and Austria 36, Great Britain and Colonies 23, Italy 11, America 3, and other countries 16. The largest contributors to the proceedings of the congress, however, were the Germans; out of a total of 117 communications, 32 were made by them, 31 by the French, 18 by the British, 15 by the Swiss, 8 by Italians, 5 by Swedes, and 2 by Americans.

From every point of view the congress was a success. Anatomy is peculiarly susceptible of international treatment, the subjects for description and discussion being concrete and capable of direct demonstration. The language difficulty certainly hindered a free discussion on more than one occasion; for instance, on the second day, a speaker, after giving his communication in French, listened most attentively to a vigorous criticism in German, and, bowing profoundly, replied, 'Je ne comprends pas l'allemand.' With an agenda list overloaded with 117 communications, there was a grave risk of disorganization. Thanks to the complete arrangements made by the committee of organization, presided over by Professor A. Êternod, of Geneva, and to the perfect arrangement of business by the president of the secrétariat, Professor von Bardeleben, the proceedings of the congress made an even and steady progress. The success of the congress must also be ascribed to Professor Nicholas, of Nancy, secretary of the French society; English members were indebted to Professor Symington, president of the British society, and to Dr. Christopher Addison, its secretary. Each day's work was divided into two parts; the morning was devoted to papers, ten minutes being allowed for each communication, and three minutes to any member who wished to criticize; the afternoon was set aside for exhibition of new specimens and demonstrations of the material on which the communications of the morning were based, and this was by far the most instructive and profitable part of the day's work. The Swiss cow-bell employed by the president of each day's proceedings (for the president of each society acted in turn as chairman) to warn the speaker that he had reached the limit of his allotted time, bound the members of the congress by a common sense of humor and materially aided the success of the meeting. In spite of the *entente cordiale*, the British anatomists associated more closely with the German than with the French members of the congress—an association determined, for the greater part, by the fact that the Germans were the superior linguists.

The members of the congress took part in the dedication of a monument to the memory of Professor Hermann Fol, who set sail from Havre in his yacht, *l'Aster,* in the spring of 1892 to investigate the fauna of the Mediterranean. From the day he sailed until now not a single trace has been discovered of ship or crew. The members of the congress were lavishly entertained by Madame Fol. The congress placed a wreath on the bust of the Swiss physiologist Servetus, who discovered the pulmonary circulation in the sixteenth century, and was burned at the stake by Calvin because, so it is said, he denied the existence of the Trinity. A wreath was placed by the British section of the congress on the spot where he was burned, this gracious act being prompted by Professor Dixon, of Trinity College, Dublin.

The congress was a social as well as a scientific success. An invitation from American anatomists to meet at Boston in 1907 was declined, as it was felt that at least a space of five years should intervene between each congress. A permanent committee for the organization of the next congress was formed by the nomination of five men, one from each of the five affiliated societies. It is intended to bring out a bulletin containing the proceedings and transactions of the congress, to which purpose part of the sum (11,000 francs) raised by subscription in Geneva to meet the expenses of the congress will be devoted. When it becomes the turn of London to entertain this congress, it will not be found an easy matter to attain the standard of hospitality which has been set by Geneva.

MAGNETIC AND ALLIED OBSERVATIONS DURING THE TOTAL SOLAR ECLIPSE OF AUGUST 30, 1905.

THE stations finally decided upon by the department of terrestrial magnetism of the Carnegie Institution of Washington in order to provide for the proper distribution and successful study of the subject under investigation were as follows:

Labrador: Battle Harbor (magnetograph, atmospheric electricity observations and declination eye-readings, the whole under the direction of J. E. Burbank, assisted by Messrs. Bowen and Homrighaus) and Turnavik (magnetic declination eye-readings by Mr. G. L. Hosmer, of the Massachusetts Institute of Technology). Both parties were supplied with full sets of absolute instruments with which important magnetic secular variation and magnetic distribution data will be obtained en route and returning. As the Canadian magnetic expedition, under the direction of Professor Stupart, located its station in Labrador within the belt of totality, the above stations were selected so as to have one immediately south of the belt and the other about the same distance north. Dr. W. G. Cady, of Wesleyan University, furthermore, made magnetic observations at Black Point, Nova Scotia, and Dr. L. A. Bauer, assisted by Professor W. C. Bauer, of Baker University, observed at Missinabi, Ontario, Canada.

In addition, Professors Elster, Geitel and Harms made atmospheric electricity observations at Palma, Majorca. It was also found that the department could avail itself of the skill and experience of Professor Palazzo, director of the meteorological and magnetic service of Italy, and so made arrangements for magnetic, electric and meteorological observations under his direction at Tripoli.

Observations were made under the auspices of the United States Coast and Geodetic Survey at Pembina, North Dakota, by Professor H. W. Fisk, of Fargo College; at Wausau, Wisconsin, by Mr. C. C. Craft; at Colebrook, New Hampshire, by Dr. G. B. Pegram, of Columbia University, and at the various magnetic observatories. At the Cheltenham Magnetic Observatory both special magnetic and electric observations were made under the direction of the observer-in-charge, Mr. W. F. Wallis.

At all of these stations the assigned program of work as published in SCIENCE was successfully carried out.

These stations in addition to those by other countries will afford a unique and most valuable collection of data covering the entire belt of totality. The hearty cooperation secured from foreign countries has been very gratifying, some of them going to considerable expense and pains. To cite but one instance, Russia in order to complete the distribution of stations along the belt of totality, sent under the auspices of the St. Petersburg Academy of Sciences, an expedition specially equipped for magnetic work and placed it under the direction of one of its most experienced magneticians, M. Dubinsky, in charge of the Pawlovsk Magnetic Observatory. Other European countries were no less zealous and likewise either sent special expeditions equipped for magnetic and electric work under the direction of able and experienced observers or made special arrangements for careful and comprehensive observations at their home stations.

According to the reports already received from observers in the United States and Canada, the eclipse interval was a rather disturbed one, due to a cosmic magnetic storm, the magnetic disturbances having in fact begun several days before the day of the eclipse. During the night of August 29 and 30, brilliant polar lights were visible at the northern stations.

At the writer's station (Missinabi, Canada, 48° 28'.6 N. and 5^h 33.9^m west of Greenwich) in addition to the disturbances already referred to, there was a smaller fluctuation about the time of maximum obscuration of the sun of the character and amount to be expected as the eclipse effect—as judged by previous eclipses. However, whether this particular fluctuation is really to be referred to the eclipse can not be stated definitely until the records have come in from other stations. If it is found that the characteristic features of

this fluctuation did not take place simultaneously at widely distant stations, but progressed in accordance with the passage of the shadow cone, the presumption will be strong that an eclipse effect has again been detected. A fuller announcement must be reserved for a later occasion.

L. A. Bauer.

Dept. Terrestrial Magnetism,
Carnegie Institution,
Washington, D. C.,
September 11, 1905.

A NATIONAL CONFERENCE OF TRUSTEES OF AMERICAN COLLEGES AND UNIVERSITIES.

A National Conference of Trustees of American Colleges and Universities will be held at the University of Illinois, Urbana, Illinois, beginning Tuesday, October 17, 1905. All trustees of such institutions and all persons who have served as trustees are cordially invited to attend.

The sessions will be held during the week in which Dr. Edmund J. James will be formally inaugurated as president of the University of Illinois. The members of the conference will be invited to attend the exercises connected with the inauguration. This will give the members of the conference an opportunity to meet representative men, presidents and professors, from many different institutions, who will be in attendance as delegates, and also to inspect the work of one of the larger of the state universities.

It is well known that the method of governing higher institutions of learning by boards of trustees, that is, bodies of non-experts—laymen, so to speak, in the field of education, —is peculiarly American.

In England the old universities are self-governing bodies, controlled largely by the faculties; in France and Germany they are departments of the government, and so far as they are not directly under the control of the government, they are autonomous, that is, ruled by the faculties. In the United States alone we felt it necessary to create a third organ, an independent, often self-renewing body of non-experts, in whose hands the entire legal control has usually been placed.

Many authorities regard this as a most satisfactory method; others find in it some of the most serious weaknesses of our American system of higher education; all believe that the problems connected with such a plan of control are far from being worked out satisfactorily.

This conference has been called for the purpose of discussing some of the most important questions of college and university administration, involving the relations of trustees, presidents and faculties. Among the questions which will be discussed are the following:

1. What should be the real administrative body of a college or university, the faculty or the trustees?

Should the trustees limit their functions to selecting a faculty and then vest in the latter the actual administration, or should the board itself undertake to administer the institution, either as a body or through its committees?

2. Should the president of the institution be the sole advisory authority to the board of trustees, or should the other administrative officers, or the various faculties, be consulted?

3. Should the faculty be authorized to nominate men to the board for vacancies, or should that be done by the president or by the committees, or by the members of the board?

4. How should trustees be selected? (*A*) By cooperation? (*B*) By the alumni? (*C*) By outside authority? (1) In case of private institutions, by the church or other body? (2) In case of state institutions: (*a*) Appointed by the governor? (*b*) Elected by the people? (*c*) Or *ex officio, e. g.*, governor, superintendent of public instruction, etc.?

5. Should the trustees assume entire control of the financial administration, or should they allow the faculties to have a representation also, by allowing them to submit a budget either by departments or as a whole?

6. Should the trustees, if they reserve the financial authority, undertake to determine the budget in all its details, or should they simply distribute by departments and leave it to the individual departments to make detailed distribution?

7. Should the trustees of all institutions, public and private alike, be required by law to file full financial statements with some public authority and publish the same?

8. Should the alumni have some formally recognized place in the scheme of government of the institution? If so, what?

9. Should the student body have formal recognition in the scheme of government by being privileged to appoint representatives to any disciplinary or administrative body?

10. Is it possible to devise uniform methods of bookkeeping and statistics, so as to make comparisons more valuable?

It will be seen that these are all vital questions, indicating difficulties which every board of trustees has to meet. It is believed that every university or college trustee will derive great aid in the performance of his duties by attending this conference and exchanging views on these important topics.

Urbana, in which the University of Illinois is located, forms with its adjoining city, Champaign, a single community of about twenty thousand inhabitants. It is situated 128 miles due south of Chicago, at the junction of three great railway systems, the Illinois Central, the Chicago, Cincinnati, Cleveland and St. Louis (Big Four), and the Wabash railways, and is thus easy of access from every direction.

Persons desiring to attend this conference should notify the undersigned as soon as possible. Suggestions as to other desirable topics for discussion will be thankfully received. Address:

DAVID KINLEY,
Dean of the College of Literature and Arts, University of Illinois,
Urbana, Illinois.

THE HARVEY SOCIETY.

THE Harvey Society, described by its constitution as 'a society for the diffusion of the knowledge of the medical sciences,' offers the following course of lectures which are to be given under the patronage of the New York Academy of Medicine:

FIRST COURSE OF HARVEY SOCIETY LECTURES, 1905–1906.

October 7, Professor Hans Meyer, 'Die Theorie der Narcose' (in German).

October 14, Professor Carl von Noorden, 'Modern Problems of Metabolism.'

November 4, Professor F. G. Novy, 'Trypanosomes.'

November 18, Dr. P. A. Levene, 'Autolysis.'

January 20, Professor W. H. Park, 'A Critical Study of Serum Therapy.'

January 27, Professor Lewellys F. Barker, 'The Neurones.'

February 2, Professor F. S. Lee, 'Fatigue.'

February 9, Professor L. B. Mendel, 'The Formation of Uric Acid.'

February 16, Professor T. H. Morgan, 'The Extent and Limitations of the Power to Regenerate in Man and other Vertebrates.'

February 23, Professor Charles S. Minot, 'On the Nature and Cause of Old Age.'

March 2, Professor J. C. Webster, 'Modern Views regarding Placentation.'

March 9, Professor Theobald Smith, 'Some Phases of Tuberculosis.'

March 16, Professor W. H. Howell, 'The Cause of the Heart Beat.'

The lectures will be held in the Academy of Medicine at half past eight on the above evenings during the winter. In the Sorbonne at Paris courses of lectures by distinguished Frenchmen and men of other lands are given with the object of bringing science before those engaged in practise and art of various pursuits. The aim of the Harvey Society is similar in character. The Harvey Society cordially invites all interested to attend this course.

SCIENTIFIC NOTES AND NEWS.

DR. W J MCGEE, U. S. Commissioner of the International Archeological and Ethnological Commission, lately chief of the department of anthropology and ethnology of the St. Louis Exposition and ethnologist in charge of the Bureau of American Ethnology, has been appointed managing director of the St. Louis Public Museum.

H. FOSTER BAIN, Ph.D. (Chicago), geologist of the U. S. Geological Survey and formerly assistant state geologist of Iowa, has been appointed state geologist of Illinois.

Dr. Melvil Dewey has resigned the directorship of the New York State Library and of the Home Education Department. It is expected that a statement may be made later in regard to the causes of Dr. Dewey's resignation and the future of the library school which he has conducted.

Dr. Henry M. Whelpley, of the medical department of Washington University, St. Louis, has been elected president of the American Conference of Pharmaceutical Faculties.

Professor S. W. Williston, of the University of Chicago, lectured on 'Ancient Sea Reptiles' at Stanford University on September 19.

Professor G. H. F. Nuttall, F.R.S., of Cambridge University, will deliver the opening address of the forthcoming winter session of the London School of Tropical Medicine on October 11.

The fourteenth annual meeting of the Association of Military Surgeons of the United States opens in Detroit on September 26. Among the foreign representatives are Dr. S. Suzuki, surgeon-general of Japan and chief surgeon of the fleets of Admiral Togo; Drs. Ho Kan Yen, of the Chinese Navy; Ying Yung Tsui, of the Chinese Army, and Wang-Hang-Chung, of the South China Army; and representatives from the British, Mexican, Canadian, Guatemalan and other foreign services.

Dr. Fridjof Nansen, who has taken a prominent part in the movement to separate Norway from Sweden, is at present in London on a special mission concerned with the status of Norway.

Professor A. G. Crampton, head of the department of physics at the College of the City of New York, has returned from Spain, where he observed the eclipse of the sun.

The expedition which Messrs. Teisserenc de Bort and Rotch sent to the tropics for the exploration of the upper air (see Science, Vol. XXII., p. 58), has returned to France on the steam-yacht *Otaria*, after a cruise of two months, during which latitude 9° N. was reached. The scientific staff, Messrs Maurice, of Trappes, and Clayton, of Blue Hill Observatory, measured the trajectories of thirteen balloons, ascended two volcanic peaks and obtained further observations of temperature, humidity and wind from twenty kite-flights. There are besides similar data from six kite-flights executed by Mr. Clayton between Boston and Gibraltar. The observations showed the existence of a southerly anti-trade in the tropics, above twelve thousand feet, and of an easterly upper-current in the equatorial region.

Three expeditions have been sent out by the University of Kansas in the last two years for the collection of vertebrate fossils. In 1904 a party in charge of Mr. H. T. Martin, assistant curator of vertebrate fossils, spent the year in Patagonia collecting from the Santa Cruz formation. During the summer of the same year another party in charge of Professor C. E. McClung, curator of the collections, worked the Cretaceous of western Kansas. A third expedition, having as its personnel Professor C. E. McClung, Mr. H. T. Martin, Mr. W. J. Baumgartner and Mr. R. G. Hoskins, has just returned from a trip to the John Day formations of central Oregon. The result of these collecting trips has been to add materially to the number of vertebrate specimens in the museum.

Dr. F. H. Snow, curator of the entomological collections of the University of Kansas, who for the last thirty years has made annual collecting trips to various parts of the United States, has conducted two expeditions into Texas and Arizona and returned with some thirty thousand specimens, many of which are new to science.

Professor Charles N. Gould, of the department of geology of the University of Oklahoma, has been granted a year's leave of absence. He expects to spend the year at the University of Nebraska and at the Johns Hopkins University, taking advanced work along certain lines. During his absence the work at the University of Oklahoma will be in charge of Professor E. G. Woodruff.

To mark the centennial of the trip of Robert Fulton's first steamboat in the Hudson River, in October, 1807, the committee on plan and scope of the Fulton Centennial Commission has recommended the construction of a memorial arch in Battery Park and the establishment of a marine museum, on a basis similar to that on which the Metropolitan Museum of Art and the American Museum of Natural History were founded.

GENERAL ISAAC J. WISTAR, of Philadelphia, founder of the Wistar Institute of Anatomy and Biology of the University of Pennsylvania, formerly president of the American Philosophical Society, died on September 18, at the age of seventy-eight years.

TOBIAS-ROBERT THALÉN, professor emeritus of physics in the Royal University of Upsala, died on July 27.

THE superintendent of the United States Coast and Geodetic Survey has received a report from Mr. W. F. Wallis in charge of the Magnetic Observatory, Cheltenham, Maryland, that the recent disastrous earthquake in Italy was recorded by the seismograph at this observatory, on the night of September 7. The principal phases in seventy-fifth meridian mean civil time counting the hours continuously through twenty-four hours, from midnight to midnight are as follows:

	North-South Component.	East-West Component.
	h m s	h m s
Beginning	21 03 20	21 03 07
Second preliminary tremor	21 07 37	21 07 43
Beginning principal portion	21 27 03	21 23 23
End principal portion	21 40 32	21 42 04
End	21 52 36	21 57 55
Maximum amplitude	21 27 18	21 24 13
Multiplying ratio	10	10
Average period of waves:	s	s
Beginning	9.0	15.2
Principal portion	15.3	16.4
End	......	16.9
Period of pendulum	About 23	About 18

THE Carnegie Institution sent professors F. Elster and H. Geitel and Herr F. Harms, to Palma to make observations of the electric conditions of the atmosphere during the recent solar eclipse. *Nature* states that by means of a self-registering electrometer, the variation of atmospheric electricity was photographically recorded, and a series of points of the same curve was taken simultaneously by eye-readings. The ionization of the air was studied, and exact measurements of the intensity of the solar radiation within the short wave-lengths were carried out. The observations, like all others in Spain, suffered from the bad weather conditions. On the day of the eclipse rain fell during the morning; consequently it can not be considered as undisturbed with regard to atmospheric electricity. The measurements of the solar radiation were possible in a continuous series only from the first contact to the end of totality; the decrease of illumination, therefore, was determined in a satisfactory manner and without any gaps. On the other hand, clouds prevented any reading being taken during the increase of light after totality.

THE U. S. Geological Survey has in hand the investigation of curious phenomena known as 'blowing' or 'breathing' wells. In the course of collecting well records, the hydrologists of the survey have observed many wells that emit currents of air with more or less force, sometimes accompanied by a whistling sound which can be heard for a long distance. The best-known examples of this type of well are found throughout the state of Nebraska. Blowing wells are also known to occur in Rapides Parish in southern Louisiana. The force of the air current in one of the Louisiana wells is sufficient to keep a man's hat suspended above it. The cause of such phenomena is mainly due to changes in atmospheric pressure or to changes in temperature. During the progress of a low-barometer storm over these regions, the air is expelled from the blowing wells. With a rising barometer, the blowing becomes rapidly less until the current is finally reversed. Differences in the temperature of the surface air and the air in the soil also produce similar effects. When the interstices between the grains of sand, gravel, etc., in which the well is driven are filled with water, the phenomena of blowing is much less noticeable. The survey will welcome any in-

formation from well owners and drillers relating to these wells.

We learn from the London *Times* that since May, 1904, correspondence has been proceeding between the Bengal government, the government of India and the Secretary of State upon the subject of the establishment of a school of mines in India, or, in lieu thereof, the making of provision for mining instruction at the Sibpur Engineering College, Calcutta, with practical instruction in the mining districts. The latter proposal was, on the advice of a representative committee of educational and mining experts, recommended by the Bengal government and has been sanctioned by the secretary of state. The course is to be for five years, including 18 months' training in the mining districts, where the students will work under the instruction of managers of mines. A professor of mining engineering is to be appointed from England at a salary of Rs.750 per mensem, rising annually by increments of Rs.50 to Rs. 1,000, which is equivalent to £800 per annum. A peripatetic mining instructor, with a native assistant, is also to be appointed, at the same salary, but without exchange compensation allowance. His work will be to give instruction to persons already engaged in mining work who desire to obtain certificates of competency. Such instruction is in all cases to be gratuitous, in view of the fact that 'owing to the extensive ignorance usually prevailing the mines are now for the most part worked upon unsystematic and wasteful lines, and that the absence of technical knowledge is a constant source of danger to the laborers.'

UNIVERSITY AND EDUCATIONAL NEWS.

By the will of the late General Isaac J. Wistar, the Wistar Institute of Anatomy and Biology of the University of Pennsylvania, founded by him, will receive the residue of his estate, thought to amount to about $400,000.

At the opening of Smith College it was announced that Mr. Andrew Carnegie had promised the sum of $125,000 to the college, providing that friends of the institution raise an equal amount. The money is to be used for the erection and maintenance of a new biological laboratory.

Mr. Andrew Carnegie has given $30,000 to Wittenberg College, Springfield, O., for a science hall, provided an additional $30,000 is raised for the upkeep of the building.

According to the report of the city comptroller of New Haven the property of Yale University exempted from taxation is valued at more than $9,000,000, an increase of nearly $2,000,000 in the past three years. This does not include the Hill House property, recently acquired at the cost of some $500,000.

On the occasion of the opening of Columbia University on September 27, the cornerstone of the new College Hall was laid, and the newly erected dormitories were open to inspection.

The library given by Mr. Andrew Carnegie to Cornell College, Mount Vernon, Iowa, was dedicated on September 13. Bishop Henry Spellmeyer, of Cincinnati and Hon. Johnson Brigham, of Des Moines, state librarian of Iowa, delivered the addresses. The building cost a little more than fifty thousand dollars. It is strictly fire proof and is built in the old colonial style of architecture. The capacity is 70,000 volumes.

On September 1, 1905, by the unanimous action of their respective boards of trustees the Medical College of Indiana was made the Medical Department of Purdue University with the title of 'Indiana Medical College School of Medicine of Purdue University.'

Cooperation between the University of Chicago and a number of railroad officers has resulted in the establishment of a four-year course in railway education.

Dr. Henry S. Drinker will be inaugurated as president of Lehigh University on October 12.

Appointments at Brown University have been made as follows: J. Ansel Brooks, assistant professor of mechanics and mechanical drawing; James F. Collins, assistant professor of botany; Henry B. Drowne, instructor in civil engineering; Charles W. Brown, instructor in geology and mineralogy.